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Feasibility of Using Plastic Pipe for Ethanol Gathering

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Results and Conclusions

General Ethanol Production Background Information

First Generation Ethanol

First generation bioethanol is produced by fermenting plant-derived sugars to ethanol, using a similar process to that used in beer and wine-making. This requires the use of 'food' crops such as sugar cane, corn, wheat, and sugar beet. These crops are required for food, so if too much biofuel is made from them, food prices could rise and shortages might be experienced in some countries. Corn, wheat and sugar beet also require high agricultural inputs in the form of fertilizers, which limit the greenhouse gas reductions that can be achieved.

The complete processing of corn to ethanol is generally done at a single facility. Most of these ethanol plants are sited in Midwestern states, close to the farms where the corn is grown. Because of this close proximity, trucks are the predominate mode for the transportation of corn to ethanol plants. Once the corn is received at the plant it is stored in silos for up to 10 days until needed for ethanol production. Liquid transportation lines within the plant are usually above ground and are constructed from low alloy steel or stainless steel.

The ethanol production process involves milling, slurrying, fermenting, distilling and purifying in a systematic manner to maximize production. At the present time, most ethanol in the US is produced from corn by either dry milling or wet milling processes. Brazil is the world's top ethanol producer, using sugar cane as the feedstock. Vehicles in that country have been using 100 percent ethanol for decades.

The dry milling process reduces the particle size of the corn using a hammer mill. The particle size of the grain can influence ethanol yield so finely ground corn (1/8 to 3/16 inch) is used to maximize ethanol yield. Water is added to start leaching soluble protein, sugars, and non-starch bound liquids. Ammonia may be added to control pH.

Wet milling is different in that the corn kernel is separated into various fractions allowing production of other products besides ethanol. The cleaned kernel is soaked in water containing sulfur dioxide and lactic acid. After soaking, the germ is removed and the starch and protein separated by filtration and centrifugation. The starch is further purified by washing to remove protein.

After milling and slurrying, starches from the corn are converted by amylolytic enzymes (enzymes capable of denaturing starch molecules) and heat into fermentable sugars (glucose). The fermentation is continued by the addition of Saccharomyces cerevisiae yeasts to produce low-grade ethanol. One by-product of the fermentation process is glycerol. Contamination by wild yeasts and microbes can be a problem, resulting in undesirable by-products such as lactic or acetic acid.

The low grade ethanol is refined by fractional distillation to produce ethanol that is 95.6% by volume (89.5 mole% or 190-proof). This mixture is an azeotrope with a boiling point of 78.1 °C and cannot be further purified by normal distillation. Desiccation, purification using molecular sieves, or azeotropic distillation is generally used to remove the remaining water.

Second Generation Ethanol

The goal of second generation biofuel processes is to extend the amount of biofuel that can be produced sustainably by using cellulosic or biomass comprised of the residual non-food parts of current crops. This includes stems, leaves and husks that are left behind once the food crop has been extracted, as well as other crops that are not used for food purposes, such as switch grass and cereals that bear little grain. Industry waste such as wood chips, skins and pulp from fruit pressing, and municipal solid waste are also used.

The major component of these cellulose-bearing materials is the fibrous material consisting of cellulose, hemicellulose, lignin, and other polysaccharides. While the refining process for cellulosic ethanol is more complex than that of corn-based ethanol, cellulosic ethanol yields a greater net energy and results in much lower greenhouse gas emissions.

The process to make ethanol from cellulosic material is not yet commercially viable from a economic perspective. Cellulose is very difficult to hydrolyze and the five-carbon sugars (pentoses) it produces are not fermentable with the yeasts normally used in ethanol production. Lignin, a partially polymerized phenolic resin, is a very undesirable contaminant.

One firm is working on techniques to make fermentation of cellulosic ethanol viable. Iogen Corporation is a privately held company, based in Ottawa, Ontario, Canada. Established in the 1970s, Iogen is one of Canada's leading biotechnology firms. They are an industrial manufacturer of enzyme products with a focus on products for use by the pulp and paper, textile and animal feed industries. Their specialty with respect to ethanol production is enzymatic fermentation. They are partnered with Shell, Goldman Sachs, Petro-Canada, and the Canadian government. With a $15.8 million investment from Petro-Canada, Iogen built the company's pre-commercial demonstration plant located in Ottawa. The company has been producing cellulosic ethanol at its demonstration plant since 2004.

Other firms are developing very different techniques to make ethanol. Coskata headquartered in Warrenville, IL is producing ethanol via the fermentation of synthesis gas, or 'syngas' mainly made up of carbon monoxide and hydrogen. Their process uses proprietary microorganisms to convert the syngas to ethanol. Syntec Biofuel also uses syngas as their feedstock, but produces ethanol by passing the gas over the catalysts in a fixed bed reactor, similar to the production process for methanol. The syngas used in both processes is generated through gasification of a variety of feedstocks.

Other research is focused on developing alternatives to the costly enzyme and yeast multi-step process. Mascoma Corporation in Lebanon, N.H., is working with a thermophilic bacterium. Oak Ridge National Laboratory researchers are studying Clostridium thermocellum which can both degrade the cellulose and ferment the resulting sugar. BC International is building a plant in Jennings, LA that uses genetically engineered E. coli bacteria to convert all forms of sugar.

Summary - Current/Common Liquid Fuels (Focused on Ethanol and Biobutanol) and What Feedstocks They Are Derived From

The common feedstocks for ethanol (biobutanol can be made from the same feedstocks as ethanol) were investigated and are summarized in Table 1 and Table 2 below.

Table 1 - Ethanol Feed Stocks (U.S. Production)

Ethanol (currently in production in U.S.)
Crops
Corn
Corn/barley
Corn/milo
Corn/wheat starch
Milo/wheat starch
Pearl millet (potential - SE US)
Waste Products
Cheese whey
Potato Waste
Wood waste
Waste beer
Beverage waste
Sugar cane bagasse
Brewery waste

Table 2 - Ethanol Feed Stocks (Non-U.S.)

Ethanol (Non-U.S.)
Sugarcane (Brazil)
Sugar beet
Wine (France/Italy)
Sake (rice wine - Japan)
Cassava (highest energy/acre - Tropical Areas)
Cellulosic biomass
Residues
Non-edible plant parts
MSW
Pulp/Paper industry waste
Wood waste
Forest residues
Dedicated crops
Grass
Short rotation trees

Biodiesel feedstocks currently in production in the U.S. are listed in Table 3.

Table 3 - Biodiesel (in U.S. Production)

Biodiesel (currently in production U.S.)
Oils
Soy
Canola
Cottonseed/soy
Cottonseed/soy/Canola
Palm
Animal Products
Yellow Grease
Animal Fat
Recycled oils and grease
Recycled Cooking oil
Waste Vegetable Oil
Multi Feedstock
Tallow/Yellow Grease/Soy/Poultry Fat
Soy/Animal Fats
Soy/Choice white grease
Cottonseed/animal fats
Plant Oils/Animal Fats
Soy/Poultry Fat

Overview of Current Transportation Methods for Ethanol

Ethanol has historically been shipped to markets via truck, rail and barge. It is stored at fuel terminals and blended with gasoline at or near the point of retail distribution. To sustain the market growth needed to meet the current suggested targets, infrastructure improvement should be considered for transporting biofuel and co-products to market.

Most ethanol is currently produced in the Midwest, but 80 percent of the U.S. population (and therefore implied ethanol demand) lives along its coastlines. Transportation factors to consider as ethanol production continues to expand include:

1. The capacity of the Nation's transportation system to move ethanol, feedstock, and co-products produced from ethanol.
2. The availability of corn close to ethanol plants (~ 50 miles).
3. The location of feedlots for use of co-products relative to ethanol producing areas.

In 2005, rail was the primary transportation mode for ethanol, shipping 60 percent of ethanol production (approximately 2.9 billion gallons of ethanol). Trucks shipped 30 percent and barges 10 percent. To date the growth of ethanol production and the construction and expansion of new plants have not been hampered by logistical concerns. Railroads kept up with ethanol growth in 2006. As ethanol production grew by 26 percent in 2006, railroads' shipments of alcohols (most of which is ethanol) increased by 28 percent.

This may not be the case in the future. All three modes used to transport ethanol—rail, barge, and truck—are at or near capacity. Total rail freight is forecast to increase from 1,879 million tons in 2002 to 3,525 million tons by 2035, an increase of nearly 88 percent.

Ethanol is shipped in the following containers.

1. Standard rail tank cars (approved for flammable liquids) - DOT 111A or AAR T108 rail cars.
2. Standard gasoline tanker trucks (DOT MC306 Bulk Fuel Haulers). Truck drivers must have HAZMAT certification.
3. The main terminals served by barge include Chicago, IL, New Orleans, LA, Houston, TX, and Albany, NY. Ethanol is typically shipped in 10,000–15,000 barrel tank barges. The number of ethanol plants located near a river facility, however, is relatively small.

Fuel transport pipelines in the United States do not currently ship ethanol or gasoline containing ethanol. The presence of water is the greatest concern. Ethanol can strip impurities present inside multi-product pipeline systems resulting in undesirable contaminants. Another factor is the evidence that ethanol can induce stress corrosion cracking, especially at untreated weld joints. Liners, weld treatments, or coatings could help alleviate this.

Water contamination poses a problem in transportation of ethanol. A large investment in dehydrating and filtration/coalescing equipment would be required for any alcohol transportation by pipeline.

The high polarity of ethanol causes problems with certain elastomers also containing polar components. Nylon swells and loses tensile strength, similar to its behavior in water. Polybutene terephthalate also exhibits significant changes. ASTM D5798 specifies that unprotected aluminum must not be used as it will introduce insoluble aluminum compounds into the fuel. The effect is exaggerated by elevated fuel conductivity due to contact with nitrile rubber.

A detailed materials compatibility study for ethanol gathering lines will be completed as part of Task 3 of this project.

GTI has finalized the steering committee selections and are in the process of scheduling the first meeting.

Plans for Future Activity

Steering Committee Meeting/Conference Call tentatively scheduled for the second or third week of December 2008.

Respectfully Submitted,

Andy Hammerschmidt & Daniel Ersoy, GTI

End of Report